EUROPEAN PATENT OFFICE

Patent Abstracts of Japan

PUBLICATION NUMBER : 01237918
PUBLICATION DATE : 22-09-89

APPLICATION DATE : 17-03-88
APPLICATION NUMBER : 63064371

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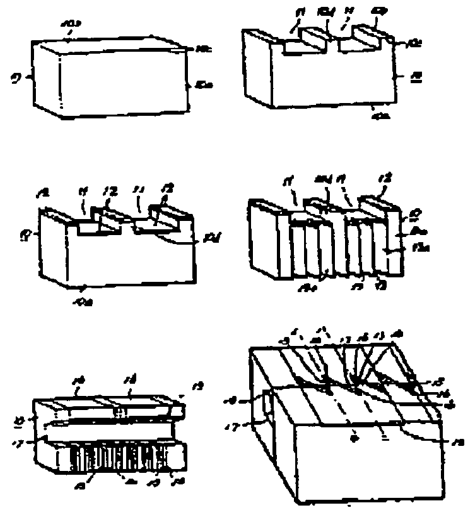
INT.CL. : G11B 5/133

TITLE : MANUFACTURE OF MAGNETIC HEAD



ABSTRACT : PURPOSE: To facilitate the preparation of a head by using a ferrite at a block material, drilling plural grooves on the sliding surface and adhering a thin film composed the non-magnetic substance with a high hardness at the whole surface including the groove, when a magnetic head is prepared.

CONSTITUTION: As a material used when a magnetic head 10 is prepared, an easy-to-work ferrite is used, a shape is made into a slender rectangular shape, the slender surface is made into a sliding surface 10b and the surface orthogonal to this is made into a gap forming surface 10a. Next, plural grooves 11 are drilled to the sliding surface 10b, and a non-magnetic thin film 12 with a high hardness such as Al_2O_3, TiO_2 and Ta_2O_5 is adhered to the bottom surface and a surface 10 protruded between plural grooves 11. Plural V-shaped grooves 13 are bored orthogonal to the grooves 11 even at the side surface and in the same way, a non-magnetic thin film 15 with the high hardness is adhered on the surface. Thereafter, the grooves 13 are crossed, a winding groove 17 is formed at the block, one more same block without having the groove 17 is glass-joined at the groove 13 side, the central part of the mutually entered grooves 13 is crossed and cut to the head with the desired size.

Pole tip recession studies of hard carbon-coated thin-film tape heads

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Hard carbon coatings were deposited by cathodic arc and direct ion beam deposition techniques on thin-film Al_2O_3–TiC heads and by the latter technique on thin-film Ni–Zn ferrite heads. Functional accelerated tests were conducted against metal particle tapes in a linear tape drive. Ion beam carbon coatings on Ni–Zn ferrite and Al_2O_3–TiC heads substantially reduced the pole tip recession observed with uncoated heads. Cathodic arc carbon coated Al_2O_3–TiC heads performed better than uncoated heads, but were less effective than the ion beam coating. Pole tip recession increased only if carbon was removed from the pole tip. This suggests that coating effectiveness is determined by its adherence to the pole tip. In two-wide pole tip heads, wear of the pole adjacent to the substrate was less than that of the other pole. Coatings withstood accelerated tests and may meet life time requirements of future heads. [S0021-8979(96)12708-6]

A major problem in thin-film recording heads is pole tip/gap recession in inductive heads.[1] Pole tip recession (relative wear of the pole tip with respect to the air bearing surface or ABS) and other damage to the head structure, which may result in signal degradation, can be minimized by depositing a thin (~5 to 20 nm) hard carbon coating over the entire ABS, including the head structure.[2–4] Sputter deposited carbon coatings are currently used in MR heads.[3,4] Cathodic arc and direct ion beam deposition techniques are highly energetic processes which are known to produce a dense and hard coating with good adhesion to the substrate.[5,6] Recent screening studies[5,6] have shown that cathodic arc and ion beam carbon coatings are superior in mechanical properties and scratch and wear resistance to sputtered and plasma-enhanced chemical vapor deposition (PECVD) carbon coatings. The objective of this research was to conduct functional tape drive tests with coated dummy Al_2O_3–TiC and Ni–Zn ferrite heads with thin-film head structure.

Al_2O_3–TiC and Ni–Zn ferrite heads (rms=1.5 nm) with IBM 3480/3490 type of construction were selected for this study, Fig. 1. One of the two modules (19 mm×3.8 mm) had the thin-film construction of an inductive write head, whereas the second module was a dummy module. The radius of the modules was 20 mm. Thick films of NiFe were electroplated and Al_2O_3 and thin films of NiFe were rf sput-

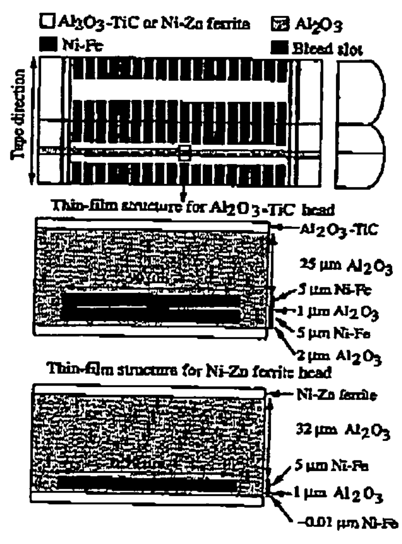

FIG. 1. Top view schematic of IBM 3480/3490 type of head and expanded view of the thin-film structure for each substrate.

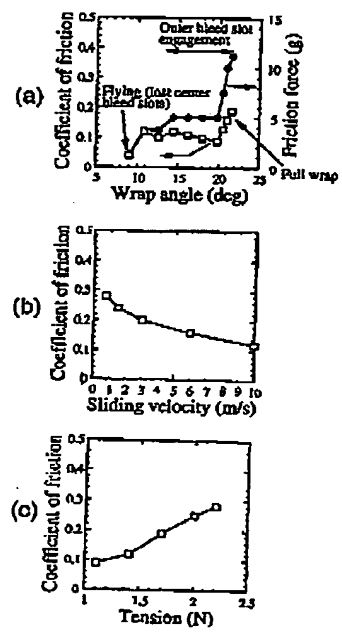

FIG. 2. Coefficient of friction and friction force at nominal experimental conditions as a function of (a) wrap angle, (b) sliding velocity, and (c) tape tension.

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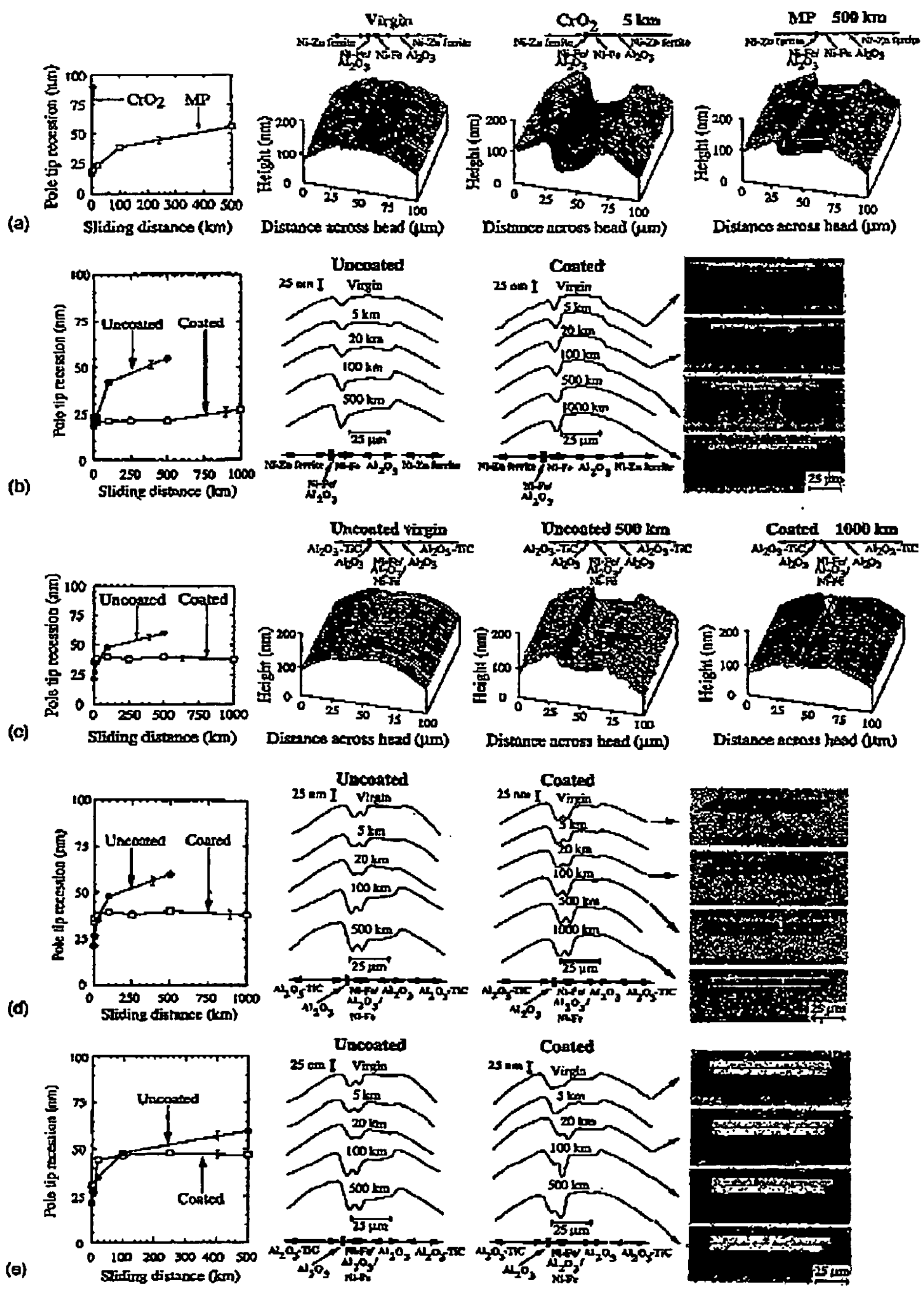

FIG. 3. Pole tip recession vs sliding distance as measured with an AFM. AFM scans across the thin-film structure at various sliding distances and optical micrographs [except (a) and (c)] of the coated thin-film structure at various sliding distances for (a) uncoated Ni–Zn ferrite heads before and after being run against CrO_2 and MP tapes, (b) uncoated and ion beam carbon coated Ni–Zn ferrite heads run against MP tape, (c) and (d) uncoated and ion beam carbon coated Al_2O_3–TiC heads run against MP tape, and (e) uncoated and cathodic arc carbon coated Al_2O_3–TiC heads run against MP tape.

tered. Al_2O_3–TiC heads have two poles with thin-film structure, and Ni–Zn ferrite heads utilize a single pole tip (Fig. 1). The hard amorphous carbon (a–C) (also referred to as diamondlike carbon) coatings with 20 nm thickness were deposited by cathodic arc and ion beam deposition techniques.[5,6] Nanoindentation hardness values of cathodic arc and ion beam carbon coatings are 38 and 19 GPa, respectively, whereas, hardness of commonly used sputtered carbon is about 15 GPa.[5] The critical load required to damage cathodic arc and ion beam coatings in microscratch experiments is more than a factor of two higher than that of the sputtered coatings.[5] The sliding tests on coated heads run against Fuji Atomm double layer video grade (substrate/total thickness $=9.8/13.2$ μm) metal particle (MP) magnetic tapes (rms=4 nm, $P-V=37$ nm)[7] were carried out using a linear tape drive (Honeywell 96) at 1.7 N of tape tension and 3 m/s sliding velocity in an ambient environment (22 ± 1 °C and $45\pm5\%$ RH) to sliding distances of 500–1000 km.[7] In normal drive operation, the tape wraps 17° over the head and engages one half of the outer bleed slots (Fig. 1), which results in a flying height of less than 100 nm. In these experiments, about 90% of the outer bleed slots were engaged by wrapping the head to increase the minimum film thickness region (which may accelerate wear by particle entrapment) and to increase the friction force (which may accelerate wear). Data in Fig. 2(a) shows an increase in both the friction force and coefficient of friction at large wrap angles. Since at low sliding velocity and high tape tension, the coefficient of friction is higher than that under the condition of entire slot engagement as shown in Figs. 2(b) and 2(c), it appears that air bearing effect is still present at the test conditions.

The pole tip recession was measured by atomic force microscope (AFM) imaging before and after the sliding tests. For recession measurements, the head was placed on a linear stage. A pole on one end was first located in an optical microscope, and then the others were located with respect to that pole. Typically, poles numbered 3, 7, 11, and 15 (out of 1 to 18) were imaged and photographed in this study to account for any variability across the tape width (Fig. 1). Pole tip recession was referenced to the substrate nearest to the pole, and the average was taken over each pole. Pole tip recession for a given condition is the average over the four chosen poles.

Figure 3(a) shows a comparison of the results obtained by running CrO_2 (rms=17.1 nm, $P-V=161$ nm) and MP tapes against uncoated Ni–Zn ferrite heads.[7] CrO_2 tape caused a large pole tip recession and catastrophic wear of the thin-film region after only 5 km of sliding distance, whereas MP tape produced smaller pole tip recession and relatively minor damage primarily in the form of scratching to the thin-film region after 500 km of sliding distance. MP tape was selected since this tape is considered for advanced thin-film head applications.

Figure 3(b) shows a comparison of the performance of uncoated and ion beam carbon coated Ni–Zn ferrite heads during sliding experiments. The pole tip recession increased with sliding distance for the uncoated head, but remained essentially constant over a larger sliding distance for the coated head (error bars in the left block represent the variability in the average pole tip recession over the four chosen poles). The 2D AFM line scans of the uncoated head show that the entire thin-film region recessed from the ABS with increased sliding distance. Optical micrographs of the coated head show that the coating remained on the pole tips through 1000 km of sliding distance which prevented growth of pole tip recession.

Figures 3(c) and 3(d) show a comparison of the performance of uncoated and ion beam carbon coated Al_2O_3–TiC heads during sliding experiments. The pole tip recession increased with sliding distance for the uncoated head, but remained essentially constant over a larger sliding distance for the coated head. The 3D [Fig. 3(c)] and 2D [Fig. 3(d)] AFM line scans show that the coating reduced the growth of recession of the entire thin-film region from the ABS with increased sliding distance as compared to that observed with the uncoated head. Optical micrographs in Fig. 3(d) show that the coating remained on the pole tips through 1000 km of sliding.

Figure 3(e) shows a comparison of the performance of uncoated and cathodic arc carbon coated Al_2O_3–TiC heads during sliding experiments. The perfomance of the cathodic arc carbon coated head in preventing pole tip recession was better than the uncoated head, but was less effective than the ion beam carbon coating. The 2D AFM line scans and optical micrographs of the coated head show that the coating was removed from the pole farthest from the substrate (bottom pole in optical micrographs) after sliding between 5 and 100 km. Further growth in recession of this pole tip after 100 km observed with the uncoated head did not occur. Further note that wear of carbon coating, when it occurred, was initiated at the pole tips which is related to the adhesion of carbon to various layers present on the substrate. Finally, no loose debris was found on the thin-film region near the pole tips in tests with uncoated and coated heads.

We thank Paul D. Reader of Ion Tech Inc. and S. Anders of Lawrence Berkeley Laboratory for coating of the heads.

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